High Performance and Polarisation Insensitive BER Assessment of a 42.66 Gbit/s All-Optical Clock Recovery

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Abstract

We propose a Bit-Error Rate assessment, and polarisation sensitivity characterization of an all-optical clock-recovery at 42.66 Gbit/s in a system environment.

Introduction

All-optical clock recovery (OCR) is extensively studied for future optical networks and especially for all-optical 3R regeneration. Semiconductor devices based on bulk material have been already proposed [1, 2]. ITU recommendation compatibility has recently been demonstrated with a new generation of self-pulsating (SP) lasers based on Quantum-Dot (QD) material [3]. The polarisation insensitivity as regard to injected optical modulated signal has been also successfully demonstrated in a dual-stage module [4]. Besides, QD structures are well-known for their intrinsic sensitivity to polarisation of the injected signal [5].

In this paper we report on a performance comparison in a system environment at 42.66 Gbit/s of self-pulsating laser OCR using bulk laser material, QD laser material and a tandem of both devices. We then compare the optical polarisation sensitivity of the three configurations. To do so, OCR configurations have been tested thanks to remodulation technique allowing the Bit Error Rate (BER) analysis [6]. The SP lasers have been designed and provided by Alcatel-Thales III-V Lab, in the framework of the French research program ROTOR.

Experimental set-up for BER measurement

The experimental set-up is presented in figure 1. The optical RZ 33% data signal from the transmitter (Tx) consists in a pseudo random binary sequence (PRBS) of 2^{31}-1 bit length at 42.66 Gbit/s (a). The wavelength used for the OCR characterisation is 1553 nm.

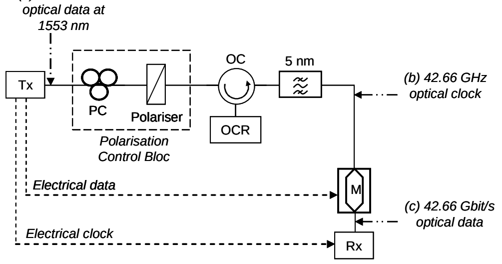

Figure 1: Experimental set-up

The polarisation control block comprises a polarisation controller (PC) and a variable polariser, allowing to modify the polarisation angle of the optical modulated signal injected in the OCR. Ahead of the OCR, an optical circulator (OC) delivers the recovered optical clock. A 5 nm optical bandpass filter is used to select the wavelength. The recovered clock (b) is then remodulated via a modulator (M) and analysed by the receiver (Rx) thanks to BER measurements (c). The clock remodulation technique has already proven its efficiency for all optical clock recovery functions validation in a transmission system environment [6]. Moreover, the high performance of our devices for OCR has already been demonstrated with input degraded data [7].

OCR configuration with bulk laser

The first configuration of OCR is constituted of the polarisation insensitive bulk SP laser, which is a Distributed Bragg Reflector (DBR) laser. The laser consists of three different sections: Bragg section, phase section and active section. A drive current of 141 mA for the gain section, and 33 mA for the Bragg section allow the self-pulsation at 42.66 GHz with an electrical linewidth of 700 kHz measured at 3 dB. The filtered output clock is centred on 1547 nm.

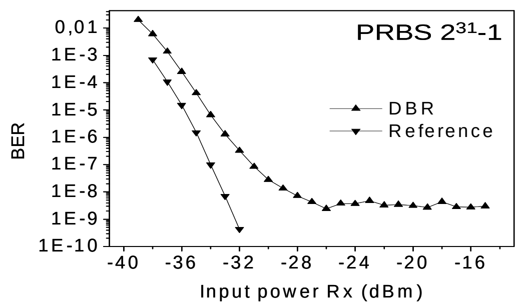

Figure 2: BER measurement for the first configuration of OCR

The optical clock recovered from optical data without degradation is then remodulated and analysed at the Rx. The results are presented in figure 2. The sensitivity reference is obtained in back to back with data from the transmitter. We measure BER versus signal power at the input of the receiver. The sensitivity curve for the remodulated recovered clock using the DBR laser is then plotted and compared to the reference. We observe a penalty of 4.5 dB for a BER of 10^{-8} and an error floor at the same BER which could not be removed. The insufficient quality of the recovered clock generated by the bulk laser was attributed to its excessive internal phase noise.

OCR configuration with QD laser

The second configuration of OCR tested here is a Fabry-Perot (FP) laser made of quantum-dot material [8]. The drive current of 412 mA allows a self-pulsation at 42.66 GHz with an electrical linewidth lower than 100 kHz at 3 dB. The QD-FP laser generates a signal around 1600 nm with a bandwidth of 10 nm. The 5 nm bandwidth optical filter is centred on 1590 nm.

At the input of the OCR, the injected signal has a linear polarisation which is collinear to the privileged polarisation axis of QD laser when the value of the polariser angle is zero. The PC placed in front of it allows a control of the optical power injected into the OCR. The curves plotted in figure 3 present the sensitivities of the remodulated clock with data for different polarisation angle values.

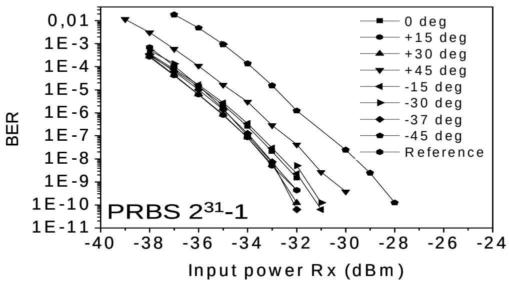

Figure 3: BER measurement for the second configuration of OCR

The first observation of the results shows no error floor as compared to the DBR alone. Secondly the OCR introduces a penalty which depends on the polarisation angle of the injected optical signal. A penalty of 3 dB is then obtained for a BER of 10^{-8} when the polarisation angle reaches -45°. So the sensitivity of the OCR composed by QD laser to the input polarisation is clearly demonstrated. With this measurement, we also demonstrated that the input polarisation angle tolerance is about +/-45°. Out of this range, the QD-FP laser is not synchronized anymore and BER measurements become impossible using the remodulation technique.

OCR configuration with the bulk and QD tandem

In the last configuration, the two previously tested lasers are cascaded and composed the OCR function. Bulk material DBR laser is placed in first position to absorb the input variations of polarization. The QD-FP laser is placed next to enhance the clock quality with respect to the previous results. In the set-up, the main polarisation axes of the lasers are aligned and the linear polarisation generated by the bulk laser is aligned with the QD laser polarisation axis. Finally, the optically recovered clock is remodulated and its quality is then assessed thanks to BER measurement. The results shown in figure 4 present the receiver sensitivity when the polarisation angle is changed.

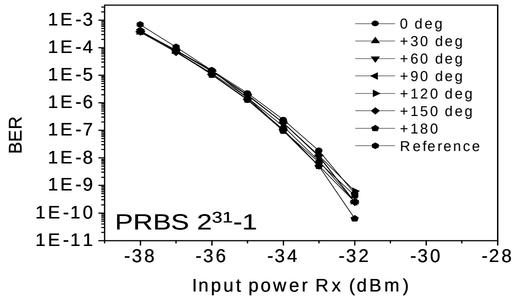

Figure 4: BER measurement for the third configuration of OCR

For polarisation angles between 0° and 180°, we obtain, with a sensitivity measurement error of 0.5 dB, neither penalty nor error floor. The experimental results show clearly the polarisation insensitivity of the tandem. This OCR has previously been successfully demonstrated system compatible in a 3R regenerator [9].

Conclusions

We present in this paper the BER assessment in system environment of an all-optical clock recovery at 42.66 Gbit/s composed of a cascade of bulk and quantum-dot self-pulsating lasers. This reliable configuration is a promising solution for future all-optical networks. Further material researches on polarisation sensitivity in QD devices would bring a more compact solution for OCR application.

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